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(54) **DISPLAY PANEL AND DISPLAY METHOD THEREOF AND DISPLAY APPARATUS**

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See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

5,904,790	A *	5/1999	Sheridon	G02B 26/026 156/250
6,515,790	B2 *	2/2003	Miyamoto	G02F 1/167 345/107

(Continued)

FOREIGN PATENT DOCUMENTS

CN	201066422	Y	5/2008
CN	102375281	A	3/2012

(Continued)

OTHER PUBLICATIONS

First Chinese Office Action (including English translation) dated Jun. 29, 2016, received for corresponding Chinese Application No. 201410270198.5.

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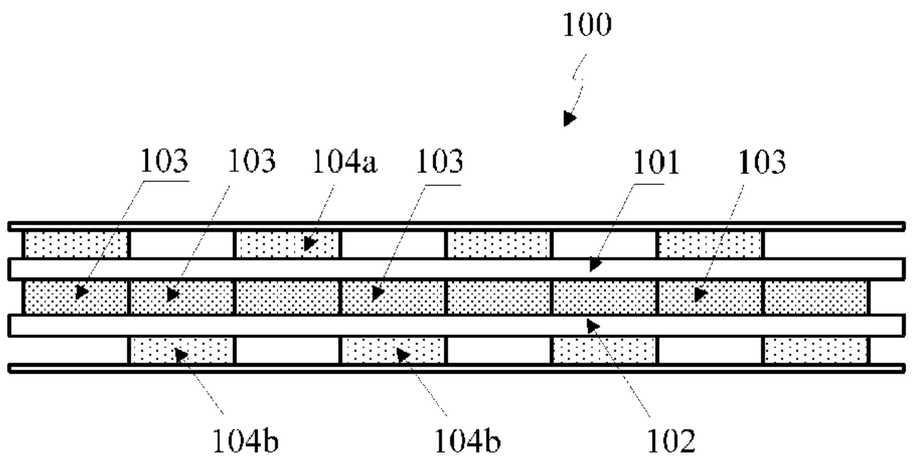
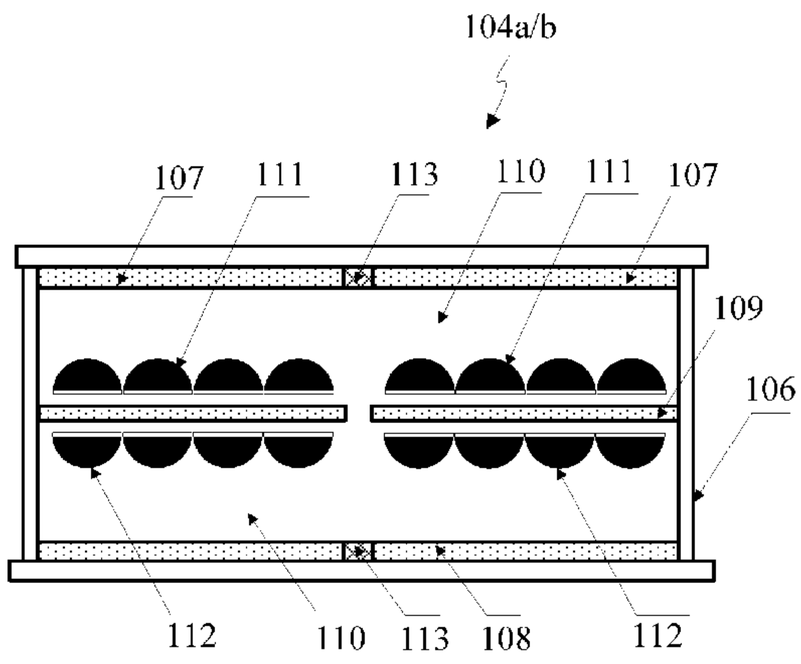
(57) **ABSTRACT**

The present disclosure provides a display panel, a display method and a display apparatus. The display panel comprises: a first transparent substrate and a second transparent substrate; a plurality of double sided light emitting pixel units located between the transparent substrates; first electrophoresis units located outside of the first transparent substrate; and second electrophoresis units located outside of the second transparent substrate. Each of the electrophoresis units comprises electrophoresis particles having a first arrangement mode and a second arrangement mode. If the electrophoresis particles in any one electrophoresis unit are in the first arrangement mode, the any one electrophoresis unit reflects a light emitted from the pixel unit; while if the electrophoresis particles in any one electrophoresis unit are in the second arrangement mode, the any one electrophoresis unit absorbs an ambient light passing through the pixel unit.

20 Claims, 2 Drawing Sheets





(56) **References Cited**

U.S. PATENT DOCUMENTS

7,492,497	B2 *	2/2009	Paolini, Jr.	G02F 1/167 345/84
8,928,575	B2 *	1/2015	Moriya	G09G 3/344 345/107
2002/0015831	A1 *	2/2002	Sheridon	G02B 26/026 428/195.1
2002/0033793	A1 *	3/2002	Machida	G02F 1/167 345/107
2002/0135861	A1 *	9/2002	Nakao	G02F 1/167 359/296
2002/0145792	A1 *	10/2002	Jacobson	B41J 2/01 359/296
2002/0196216	A1 *	12/2002	Tokuyo	G09F 9/372 345/84
2002/0196219	A1 *	12/2002	Matsunaga	G09G 3/344 345/87
2003/0048370	A1 *	3/2003	Koyama	G09G 3/344 348/311
2003/0063076	A1 *	4/2003	Machida	G09G 3/2085 345/204
2003/0231162	A1 *	12/2003	Kishi	G02F 1/167 345/107
2004/0169912	A1 *	9/2004	Liang	G02F 1/167 359/296
2005/0035941	A1	2/2005	Albert et al.	
2006/0289857	A1 *	12/2006	Kuo	H01L 27/3286 257/40
2007/0064173	A1 *	3/2007	Chiu	G02F 1/133603 349/69
2007/0194702	A1 *	8/2007	Jeng	H01L 27/326 313/506
2007/0195399	A1 *	8/2007	Aylward	G02F 1/1347 359/296
2007/0207571	A1 *	9/2007	Morisue	H01L 27/1214 438/107
2008/0024427	A1 *	1/2008	Kuo	G02F 1/136204 345/107
2008/0272987	A1 *	11/2008	Lee	G02F 1/167 345/55
2008/0316581	A1 *	12/2008	Moriya	G02F 1/167 359/296
2010/0164903	A1 *	7/2010	Lee	G06F 3/0412 345/174
2011/0007046	A1 *	1/2011	Tsai	G02B 26/005 345/207
2012/0250141	A1 *	10/2012	Chen	G02B 1/06 359/320

FOREIGN PATENT DOCUMENTS

CN	103094312	A	5/2013
CN	103353701	A	10/2013
JP	2013037247	A	2/2013
KR	20130045125	A	5/2013

* cited by examiner

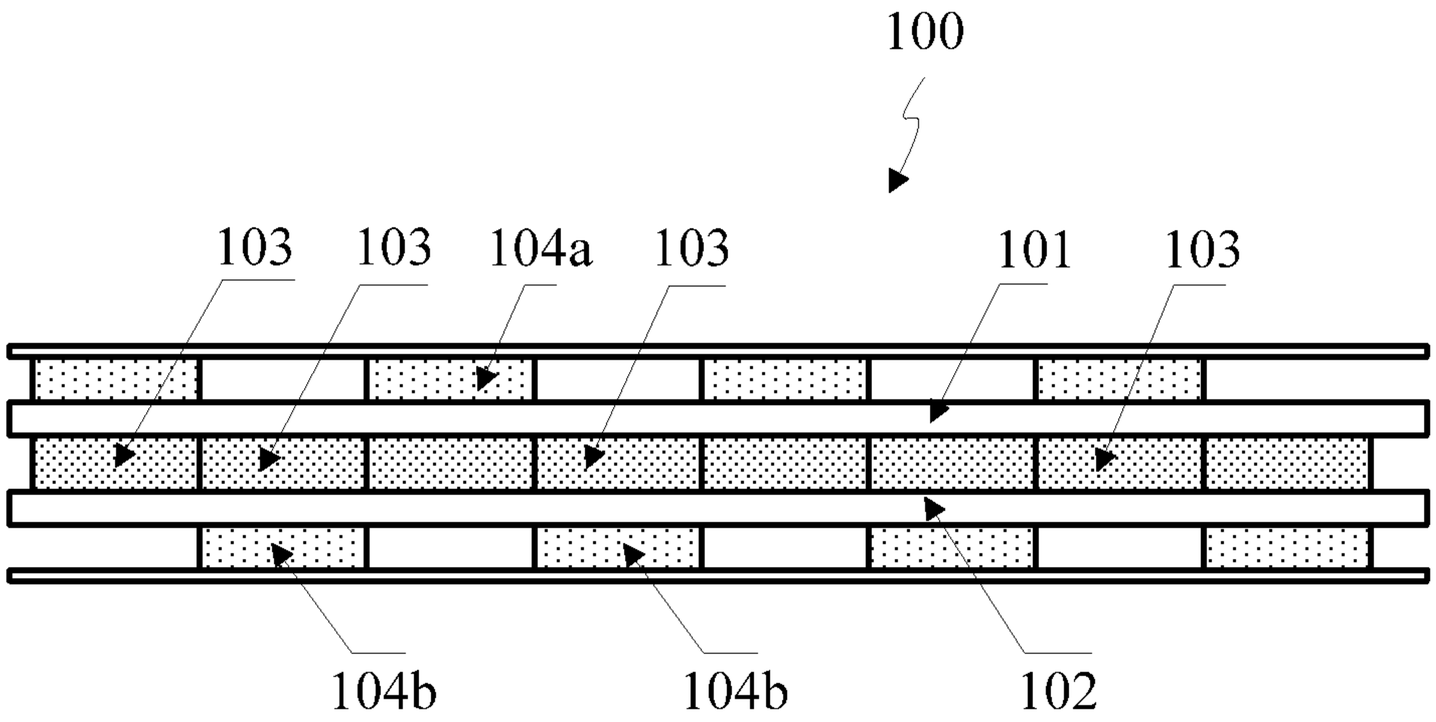


Fig.1

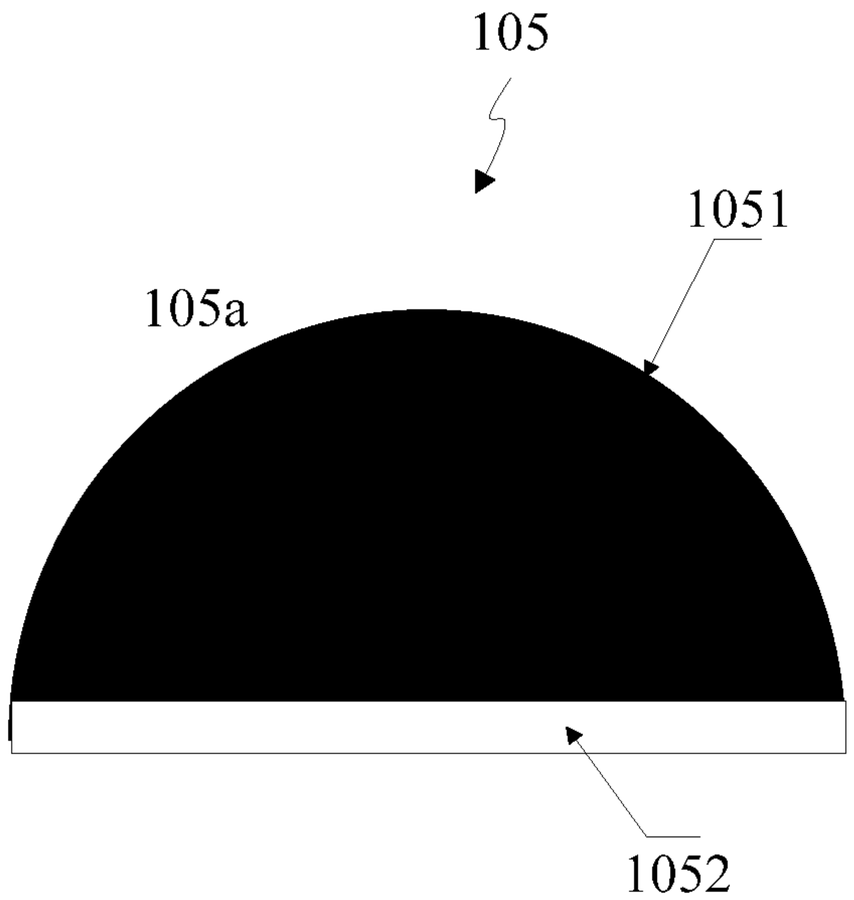


Fig.2

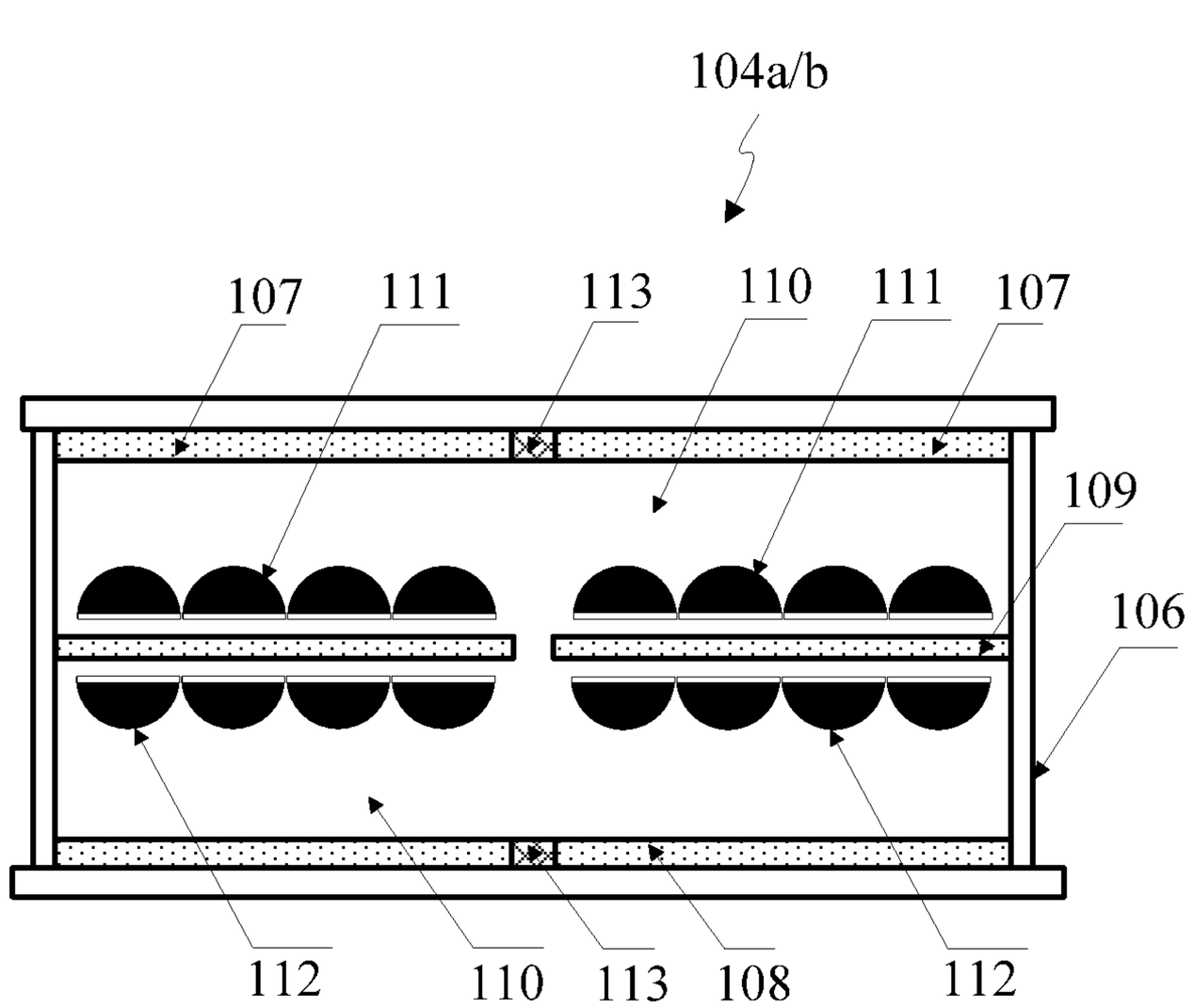


Fig.3

DISPLAY PANEL AND DISPLAY METHOD THEREOF AND DISPLAY APPARATUS

CROSS-REFERENCE TO RELATED APPLICATION

This application claims the benefit of Chinese Patent Application No. 201410270198.5 filed on Jun. 17, 2014 in the State Intellectual Property Office of China, the whole disclosure of which is incorporated herein by reference.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present disclosure relates to a technical field of display, more particularly, relates to a display panel, a display method for the display panel and a display apparatus.

2. Description of the Related Art

As the information transmission evolves and light and thin electronic products develop, the requirements of the people to the display panel are varying continuously. For example, applications for bulletin boards of public traffic hub, information display plates on windows of a business hall need the display apparatus can achieve a double-sided display in convenience of users. Further, portable electronic products also need the double-sided display to extend the picture space and switch and process more operations rapidly.

At present, the double sided display panel in industries is typically formed as follows: for example, it may be formed by adhering two single sided display panels to each other, each of which has its separate driving system. However, in this way, the cost for producing the double sided display panel is relatively high and the resultant double-sided display panel has a relatively large thickness, and thus the effect is not good; alternatively, for example, it may be formed by providing two light emitting regions, each of which has a reflective layer to reflect a light in a direction opposite to the light emitting direction, on the same substrate, the two light emitting regions having different light emitting directions. However, in this way, when a light emitting region is in a non-display state, it still reflects the ambient light, which causes an undesired contrast for the ambient light. Also for example, two light emitting regions are provided on the same substrate with electrophoresis layers on both sides thereof such that a certain light emitting region may absorb the ambient light when it is in the non-display state. However, in this way, when the light emitting region is in a display state, the electrophoresis layers will not reflect the light in the direction opposite to the light emitting direction, which causes undesired display brightness.

SUMMARY OF THE INVENTION

The present disclosure provides a display panel, a display method for the display panel and a display apparatus. With technical solutions disclosed herein, a light and thin double-sided display apparatus may be achieved with relative low costs and may have relative high display brightness and ambient light contrast.

According to an embodiment of the present invention, it provides a display panel comprising: a first transparent substrate and a second transparent substrate opposed to each other; a plurality of double sided light emitting pixel units located between the first transparent substrate and the second transparent substrate and arranged in a matrix; a plurality of first electrophoresis units located outside of the first transparent substrate and corresponding to odd numbered rows of the pixel units one by one; a plurality of second electrophoresis units located outside of the second transparent substrate and corresponding to even numbered rows of the pixel units one by one, wherein each of the first electrophoresis units and the second electrophoresis units comprises a plurality of electrophoresis particles having a first arrangement mode and a second arrangement mode, and wherein if the electrophoresis particles in any one electrophoresis unit of the first electrophoresis units and the second electrophoresis units are in the first arrangement mode, the any one electrophoresis unit reflects a light emitted from the pixel unit corresponding to the any one electrophoresis unit while if the electrophoresis particles in any one electrophoresis unit of the first electrophoresis units and the second electrophoresis units are in the second arrangement mode, the any one electrophoresis unit absorbs an ambient light passing through the pixel unit corresponding to the any one electrophoresis unit.

According to an embodiment of the present invention, it provides display apparatus comprising a display panel, the display panel comprising:

a first transparent substrate and a second transparent substrate opposed to each other;

a plurality of double sided light emitting pixel units located between the first transparent substrate and the second transparent substrate and arranged in a matrix;

a plurality of first electrophoresis units located outside of the first transparent substrate and corresponding to odd numbered rows of the pixel units one by one;

a plurality of second electrophoresis units located outside of the second transparent substrate and corresponding to even numbered rows of the pixel units one by one,

wherein each of the first electrophoresis units and the second electrophoresis units comprises a plurality of electrophoresis particles having a first arrangement mode and a second arrangement mode, and

wherein if the electrophoresis particles in any one electrophoresis unit of the first electrophoresis units and the second electrophoresis units are in the first arrangement mode, the any one electrophoresis unit reflects a light emitted from the pixel unit corresponding to the any one electrophoresis unit while if the electrophoresis particles in any one electrophoresis unit of the first electrophoresis units and the second electrophoresis units are in the second arrangement mode, the any one electrophoresis unit absorbs an ambient light passing through the pixel unit corresponding to the any one electrophoresis unit.

According to an embodiment of the present invention, it provides a display method for a display panel, the display panel comprising:

a first transparent substrate and a second transparent substrate opposed to each other;

a plurality of double sided light emitting pixel units located between the first transparent substrate and the second transparent substrate and arranged in a matrix;

a plurality of first electrophoresis units located outside of the first transparent substrate and corresponding to odd numbered rows of the pixel units one by one;

a plurality of second electrophoresis units located outside of the second transparent substrate and corresponding to even numbered rows of the pixel units one by one,

wherein each of the first electrophoresis units and the second electrophoresis units comprises a plurality of electrophoresis particles having a first arrangement mode and a second arrangement mode, and

wherein if the electrophoresis particles in any one electrophoresis unit of the first electrophoresis units and the second electrophoresis units are in the first arrangement mode, the any one electrophoresis unit reflects a light emitted from the pixel unit corresponding to the any one electrophoresis unit while if the electrophoresis particles in any one electrophoresis unit of the first electrophoresis units and the second electrophoresis units are in the second arrangement mode, the any one electrophoresis unit absorbs an ambient light passing through the pixel unit corresponding to the any one electrophoresis unit,

the method comprising:

controlling the arrangement modes of the electrophoresis particles such that the electrophoresis particles in the electrophoresis units corresponding to the pixel units in a display state is in the first arrangement mode while the electrophoresis particles in the electrophoresis units corresponding to the pixel units in a non-display state is in the second arrangement mode.

BRIEF DESCRIPTION OF THE DRAWINGS

The above and other features of the present invention will become more apparent by describing in detail exemplary embodiments thereof with reference to the accompanying drawings. Throughout drawings, same or similar members are indicated by same reference numerals.

FIG. **1** is an illustrative structure view of a display panel according to an embodiment of the present invention;

FIG. **2** is an illustrative structure view of electrophoresis particles according to an embodiment of the present invention; and

FIG. **3** is an illustrative structure view of a first or second electrophoresis unit according to an embodiment of the present invention.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS OF THE INVENTION

Exemplary embodiments of the present disclosure will be described hereinafter in detail with reference to the attached drawings, wherein the like reference numerals refer to the like elements. The present disclosure may, however, be embodied in many different forms and should not be construed as being limited to the embodiment set forth herein; rather, these embodiments are provided so that the present disclosure will be thorough and complete, and will fully convey the concept of the disclosure to those skilled in the art.

According to a general inventive concept of the present invention, there is provided a display panel comprising: a first transparent substrate and a second transparent substrate opposed to each other; a plurality of double sided light emitting pixel units located between the first transparent substrate and the second transparent substrate and arranged in a matrix; a plurality of first electrophoresis units located outside of the first transparent substrate and corresponding to odd numbered rows of the pixel units one by one; a plurality of second electrophoresis units located outside of the second transparent substrate and corresponding to even numbered rows of the pixel units one by one, wherein each of the first electrophoresis units and the second electrophoresis units comprises a plurality of electrophoresis particles having a first arrangement mode and a second arrangement mode, and wherein if the electrophoresis particles in any one electrophoresis unit of the first electrophoresis units and the second electrophoresis units are in the first arrangement mode, the any one electrophoresis unit reflects a light emitted from the pixel unit corresponding to the any one electrophoresis unit while if the electrophoresis particles in any one electrophoresis unit of the first electrophoresis units and the second electrophoresis units are in the second arrangement mode, the any one electrophoresis unit absorbs an ambient light passing through the pixel unit corresponding to the any one electrophoresis unit.

In the following detailed description, for purposes of explanation, numerous specific details are set forth in order to provide a thorough understanding of the disclosed embodiments. It will be apparent, however, that one or more embodiments may be practiced without these specific details. In other instances, well-known structures and devices are schematically shown in order to simplify the drawing.

As illustrated in FIG. **1**, an embodiment of the present invention provides a display panel **100** comprising: a first transparent substrate **101** and a second transparent substrate **102** opposed to each other; a plurality of double sided light emitting pixel units **103** located between the first transparent substrate **101** and the second transparent substrate **102** and arranged in a matrix. In an embodiment, the double sided light emitting pixel units **103** can emit a light towards the first transparent substrate **101** and the second transparent substrate **102** on its both sides respectively. As an example, the pixel unit **103** may be a pixel at least comprising red, green and blue sub-pixels. It may also include a transparent sub-pixel. It may be a red, green, blue or transparent sub-pixel.

In an embodiment, the display panel **100** may further include:

a plurality of first electrophoresis units **104***a* which are located outside of the first transparent substrate **101** and corresponds to odd numbered rows of the pixel units **103** one by one; and a plurality of second electrophoresis units **104***b* which are located outside of the second transparent substrate **102** and corresponds to even numbered rows of the pixel units **103** one by one. As illustrated in FIG. **1**, the first electrophoresis units **104***a* and the second electrophoresis units **104***b* are distributed alternatively on two sides of an assembly composed of the first transparent substrate **101**, the pixel units **103** and the second transparent substrate **102**, respectively.

As an example, the pixel unit **103** may be at least partially transparent, which may allow at least a part of ambient light to pass through it, in particular when the pixel unit **103** is in a non-display state.

Each of the first electrophoresis units **104***a* and the second electrophoresis units **104***b* comprises a plurality of electrophoresis particles (as shown in FIG. **2**). In an embodiment, the electrophoresis particles **105** have a first arrangement mode and a second arrangement mode. And if the electrophoresis particles **105** in any one electrophoresis unit of the first electrophoresis units **104***a* and the second electrophoresis units **104***b* are in the first arrangement mode, the any one electrophoresis unit reflects a light emitted from the pixel unit **103** corresponding to the any one electrophoresis unit while if the electrophoresis particles **105** in any one electrophoresis unit of the first electrophoresis units **104***a* and the second electrophoresis units **104***b* are in the second arrangement mode, the any one electrophoresis unit absorbs an ambient light passing through the pixel unit **103** corresponding to the any one electrophoresis unit.

As an example, the first electrophoresis units **104***a* and/or the second electrophoresis units **104***b* may be configured to control the arrangement modes of the electrophoresis par-

ticles **105** such that the electrophoresis particles **105** in the electrophoresis units corresponding to the pixel units in a display state are in the first arrangement mode while the electrophoresis particles in the electrophoresis units corresponding to the pixel units **103** in a non-display state are in the second arrangement mode. As an example, the arrangement mode of the electrophoresis particles **105** may include arrangement such as for the direction, posture of the electrophoresis particles **105**. By means of controlling the arrangement mode of the electrophoresis particles **105**, the first electrophoresis units **104***a* and the second electrophoresis units **104***b* may be configured to reflect the light emitted from the pixel units **103** in the display state corresponding to the electrophoresis unit while absorbing the ambient light passing through the pixel units **103** in the non-display state corresponding to the electrophoresis unit.

It should be noted that, when the electrophoresis particles **105** are in the first arrangement mode or the second arrangement mode, it is not necessary that all of the electrophoresis particles **105** are in the same direction or posture. For example, some of the electrophoresis particles **105** may be in one direction or posture while the other electrophoresis particles **105** may be in another direction or posture. Alternatively, all of the electrophoresis particles **105** may be in the same direction or posture.

In an embodiment, the electrophoresis particles **105** may be in a shape of spherical segment. For example, the electrophoresis particles **105** may be in a shape of hemisphere. It is helpful to change the arrangement modes of the electrophoresis particles **105**, for example by inverting, while taking account into light absorbing or reflecting areas of the electrophoresis particles **105**.

In an embodiment, the display panel **100** may allow the odd numbered rows or even numbered rows of pixel units to display individually, so as to achieve a single sided display. At this time, the first electrophoresis units **104***a* or the second electrophoresis units **104***b* corresponding to the odd numbered rows or even numbered rows of the pixel units **103** in the display state reflect the light emitted from the pixel units **103** while the second electrophoresis units **104***b* or the first electrophoresis units **104***a* corresponding to the pixel units **103** in the non-display state absorb the ambient light. As an example, the display panel **100** may also drive the odd numbered rows and even numbered rows of the pixel units **103** in time-sharing to carry out the display operation alternatively. In this example, the odd numbered rows and even numbered rows of the pixel units **103** have different display directions to achieve the double sided display. Likewise, the first electrophoresis units **104***a* or the second electrophoresis units **104***b* corresponding to the odd numbered rows or even numbered rows of the pixel units **103** in the display state reflect the light emitted from the pixel units **103** while the second electrophoresis units **104***b* or the first electrophoresis units **104***a* corresponding to the pixel units **103** in the non-display state absorb the ambient light. As an example, the first electrophoresis units **104***a* and the second electrophoresis units **104***b* may be driven along with the odd numbered rows or even numbered rows of the pixel units **103**. The time-sharing driving of the odd numbered rows or even numbered rows of the pixel units **103** is well known for the skilled person in the art. Thus, its details are omitted herein.

As an example, as illustrated in FIG. **2**, the electrophoresis particle **105** may have a spherical segment portion **105***a* and a reflective layer **1052** at a bottom of the spherical segment portion **105***a*, the spherical segment portion **105***a* having a spherical surface which is a light absorbing surface **1051**. As an example, the light absorbing surface **1051** may be black while the reflective layer **1052** may be white.

FIG. **3** shows schematically a structure of the first electrophoresis units **104***a*/the second electrophoresis units **104***b*. Each electrophoresis unit of the first and second electrophoresis units may comprise a chamber **106** filled with a transparent liquid **110**. The chamber **106** may have an upper wall with a first transparent electrode layer **107** and a lower wall with a second transparent electrode layer **108**, and a third transparent electrode layer **109** may be located between the first transparent electrode layer **107** and the second transparent electrode layer **108**. The first transparent electrode layer **107**, the second transparent electrode layer **108** and the third transparent electrode layer **109** may be spaced apart by the transparent liquid **110**. As an example, the chamber **106** may be full of the transparent liquid **110**.

As an example, the first electrophoresis units **104***a* and the second electrophoresis units **104***b* may have the substantially same structure.

As an example, the electrophoresis particles **105** may include first electrophoresis particles **111** and second electrophoresis particles **112**, the first electrophoresis particles **111** and the second electrophoresis particles **112** having opposite whole polarities to each other.

As an example, the first electrophoresis particles **111** are located between the first transparent electrode layer **107** and the third transparent electrode layer **109** and the second electrophoresis particles **112** are located between the second transparent electrode layer **108** and the third transparent electrode layer **109**. Or, the second electrophoresis particles **112** are located between the first transparent electrode layer **107** and the third transparent electrode layer **109** and the first electrophoresis particles **111** are located between the second transparent electrode layer **108** and the third transparent electrode layer **109**.

As an example, the reflective layers **1052** of the first electrophoresis particles **111** face towards the reflective layers **1052** of the second electrophoresis particles **112** in the electrophoresis units corresponding to the pixel units **103** in the non-display state. For example, when the display panel **100** is in the non-display state in whole, in all of the first electrophoresis units **104***a* and second electrophoresis units **104***b*, the reflective layers **1052** of the first electrophoresis particles **111** face towards the reflective layers **1052** of the second electrophoresis particles **112**. In contrast, the reflective layers **1052** of the first electrophoresis particles **111** and the reflective layers **1052** of the second electrophoresis particles **112** in the electrophoresis units corresponding to the pixel units **103** in the display state both face towards the pixel units **103**.

In an embodiment, each of the first transparent electrode layer **107** and the second transparent electrode layer **108** includes two transparent electrodes and a masking bar **113** is provided between two transparent electrodes in the same electrode layer.

In order that the first electrophoresis units **104***a*/the second electrophoresis units **104***b* corresponding to the pixel units **103** in the display state reflect the light emitted from the pixel units **103** while the first electrophoresis units **104***a*/the second electrophoresis units **104***b* corresponding to the pixel units **103** in the non-display state absorb the ambient light. As an example, the spherical segment portions of the first electrophoresis particles **111** have positive polarities while the reflective layers **1052** of the first electrophoresis particles **111** have negative polarities and the first electrophoresis particles **111** have negative polarities in whole. And further, the spherical segment portions of the

second electrophoresis particles **112** have negative polarities while the reflective layers **1052** of the second electrophoresis particles **112** have positive polarities and the second electrophoresis particles **112** have positive polarities in whole. Or, as an example, the spherical segment portions of the first electrophoresis particles **111** have negative polarities while the reflective layers **1052** of the first electrophoresis particles **111** have positive polarities and the first electrophoresis particles **111** have positive polarities in whole. And further, the spherical segment portions of the second electrophoresis particles **112** have positive polarities while the reflective layers **1052** of the second electrophoresis particles **112** have negative polarities and the second electrophoresis particles **112** have negative polarities in whole. Typically, the spherical segment portion and the light absorbing surface **1051** are integrated, thus the light absorbing surface **1051** has the same polarity as that of the spherical segment portion.

Meanwhile, it should be noted that the spherical surfaces of the spherical segment portions of the first electrophoresis particles **111** and the second electrophoresis particles **112** both absorb the ambient light in external when the reflective layers **1052** of the first electrophoresis particles **111** face towards the reflective layers **1052** of the second electrophoresis particles **112**, i.e., the electrophoresis particles **105** are in the second arrangement mode, which is benefit to improve the contrast. In contrast, the reflective layers **1052** of the first electrophoresis particles **111** and the second electrophoresis particles **112** may both reflect the light emitted from the pixel units **103** when the reflective layers **1052** of the first electrophoresis particles **111** and the reflective layers **1052** of the second electrophoresis particles **112** face towards the pixel units **103**, i.e., the electrophoresis particles **105** are in the first arrangement mode, which is benefit to improve the display brightness.

As an example, change of the arrangement modes of the electrophoresis particles **105** may be achieved by inverting the first electrophoresis particles **111** and/or the second electrophoresis particles **112**.

As an example, the number of the first electrophoresis particles **111** is equal to the number of the second electrophoresis particles **112** in a single electrophoresis unit. However, the present invention is not limited to this, for example, the number of the first electrophoresis particles **111** may alternatively be different from the number of the second electrophoresis particles **112**.

An embodiment of the present invention may take the following advantageous effects: with the first electrophoresis units corresponding to the odd numbered rows of the pixel units provided on one side of the display panel and the second electrophoresis units corresponding to the even numbered rows of the pixel units provided on the other side of the display panel, the single sided display may be achieved by the odd numbered rows or even numbered rows of the pixel units by controlling the arrangement modes of the electrophoresis particles in the first and/or second electrophoresis units. Or, the double sided display may be achieved by controlling the odd numbered rows and even numbered rows of the pixel units in a time-sharing manner. Meanwhile, the light emitted from the pixel units in the display state may be reflected while the ambient light passing through the pixel units in the non-display state may be absorbed, which may improve the display brightness and ambient light contrast of the display panel.

An embodiment of the present invention also provides a display apparatus comprising the display panel as described in any one of the embodiments.

An embodiment of the present invention also provides a display method for a display panel. The display panel may be that described in any one of the embodiments. The display method includes:

controlling the arrangement modes of the electrophoresis particles **105** in the first electrophoresis units **104***a* and/or the second electrophoresis units **104***b* such that the electrophoresis particles **105** in the electrophoresis units corresponding to the pixel units **103** in the display state are in the first arrangement mode while the electrophoresis particles **105** in the electrophoresis units corresponding to the pixel units **103** in the non-display state are in the second arrangement mode.

As an example, in relation to the embodiment of the first/second electrophoresis units as shown in FIG. **3**, in the method, the step of controlling the arrangement modes of the electrophoresis particles may comprise:

if a pixel unit is in the display state, applying a control voltage to the third transparent electrode layer such that the reflective layers of the first electrophoresis particles and the reflective layers of the second electrophoresis particles in the electrophoresis unit corresponding to the pixel unit both face towards the pixel unit in the display state to make the reflective layers of the first electrophoresis particles and the reflective layers of the second electrophoresis particles reflect the light emitted from the pixel unit in the display state.

As an example, in the method, the step of controlling the arrangement modes of the electrophoresis particles may further comprise:

if a pixel unit is in the non-display state, removing or not applying a control voltage to the third transparent electrode layer such that the reflective layers of the first electrophoresis particles face towards the reflective layers of the second electrophoresis particles to make the spherical segment portions of the first electrophoresis particles or the spherical segment portions of the second electrophoresis particles absorb the ambient light passing through the pixel unit in the non-display state corresponding to the electrophoresis unit.

In case that the first electrophoresis particles and the second electrophoresis particles have opposite whole polarities to each other, the whole polarities of the first electrophoresis particles and the second electrophoresis particles may be:

the spherical segment portions of the first electrophoresis particles have positive polarities while the reflective layers of the first electrophoresis particles have negative polarities and the first electrophoresis particles have negative polarities in whole; and the spherical segment portions of the second electrophoresis particles have negative polarities while the reflective layers of the second electrophoresis particles have positive polarities and the second electrophoresis particles have positive polarities in whole; or

the spherical segment portions of the first electrophoresis particles have negative polarities while the reflective layers of the first electrophoresis particles have positive polarities and the first electrophoresis particles have positive polarities in whole; and the spherical segment portions of the second electrophoresis particles have positive polarities while the reflective layers of the second electrophoresis particles have negative polarities and the second electrophoresis particles have negative polarities in whole.

Thus, when any one electrophoresis particle of the first electrophoresis particles and the second electrophoresis particles needs to be inverted, their polarities in absence of the control voltage applied to the third transparent electrode

layer need to be set depending on the above two cases of the first electrophoresis particles and the second electrophoresis particles.

For example, the spherical segment portions of the first electrophoresis particles have positive polarities while the reflective layers of the first electrophoresis particles have negative polarities and the first electrophoresis particles have negative polarities in whole; and the spherical segment portions of the second electrophoresis particles have negative polarities while the reflective layers of the second electrophoresis particles have positive polarities and the second electrophoresis particles have positive polarities in whole.

In this circumstance, if the second electrophoresis particles need to be inverted, a positive voltage is applied to the third transparent electrode layer such that the first electrophoresis particles are not inverted while the second electrophoresis particles are inverted; and

if the first electrophoresis particles need to be inverted, a negative voltage is applied to the third transparent electrode layer such that the second electrophoresis particles are not inverted while the first electrophoresis particles are inverted.

An embodiment of the present invention may take the following advantageous effects: with the first electrophoresis units corresponding to the odd numbered rows of the pixel units provided on one side of the display panel and the second electrophoresis units corresponding to the even numbered rows of the pixel units provided on the other side of the display panel, the single sided display may be achieved through the odd numbered rows or even numbered rows of the pixel units by controlling the arrangement modes of the electrophoresis particles in the first and/or second electrophoresis units. Or, the double sided display may be achieved by controlling the odd numbered rows and even numbered rows of the pixel units in the time-sharing manner. Meanwhile, the light emitted from the pixel units in the display state may be reflected while the ambient light passing through the pixel units in the non-display state may be absorbed, which may improve the display brightness and ambient light contrast of the display panel.

Although several exemplary embodiments have been shown and described, the present invention is not limited to those and it would be appreciated by those skilled in the art that various changes or modifications may be made in these embodiments without departing from the principles and spirit of the disclosure, the scope of which is defined in the claims and their equivalents.

What is claimed is:

1. A display panel, comprising:

a first transparent substrate and a second transparent substrate opposed to each other;

a plurality of double sided light emitting pixel units located between the first transparent substrate and the second transparent substrate and arranged in a matrix;

a plurality of first electrophoresis units located outside of the first transparent substrate and corresponding to odd numbered rows of the pixel units one by one;

a plurality of second electrophoresis units located outside of the second transparent substrate and corresponding to even numbered rows of the pixel units one by one,

wherein each of the first electrophoresis units and the second electrophoresis units comprises a plurality of electrophoresis particles having a first arrangement mode and a second arrangement mode, and

wherein in response to the electrophoresis particles in any first one electrophoresis unit of the first electrophoresis units and the second electrophoresis units being in the first arrangement mode, the first one electrophoresis unit reflects a light emitted from the pixel unit corresponding to the first one electrophoresis unit, while in response to the electrophoresis particles in any second one electrophoresis unit of the first electrophoresis units and the second electrophoresis units being in the second arrangement mode, the second one electrophoresis unit absorbs an ambient light passing through the pixel unit corresponding to the second one electrophoresis unit.

2. The display panel according to claim **1**, wherein the first electrophoresis units and/or the second electrophoresis units are configured to control the arrangement modes of the electrophoresis particles such that the electrophoresis particles in the electrophoresis units corresponding to the pixel units in a display state are in the first arrangement mode, while the electrophoresis particles in the electrophoresis units corresponding to the pixel units in a non-display state are in the second arrangement mode.

3. The display panel according to claim **1**, wherein the electrophoresis particles are in a shape of spherical segment.

4. The display panel according to claim **3**, wherein the electrophoresis particles are in a shape of hemisphere.

5. The display panel according to claim **1**, wherein each electrophoresis unit of the first and second electrophoresis units further comprises a chamber filled with a transparent liquid, the chamber comprising an upper wall with a first transparent electrode layer and a lower wall with a second transparent electrode layer, and a third transparent electrode layer being located between the first transparent electrode layer and the second transparent electrode layer, and the first, second and third transparent electrode layers being spaced apart by the transparent liquid;

wherein the electrophoresis particles comprise first electrophoresis particles and second electrophoresis particles, the first electrophoresis particles and the second electrophoresis particles having opposite whole polarities to each other;

wherein the first electrophoresis particles are located between the first transparent electrode layer and the third transparent electrode layer, and the second electrophoresis particles are located between the second transparent electrode layer and the third transparent electrode layer; or

the second electrophoresis particles are located between the first transparent electrode layer and the third transparent electrode layer, and the first electrophoresis particles are located between the second transparent electrode layer and the third transparent electrode layer.

6. The display panel according to claim **5**, wherein each of the first transparent electrode layer and the second transparent electrode layer comprises two transparent electrodes and a masking bar is provided between the two transparent electrodes in the same electrode layer.

7. The display panel according to claim **5**, wherein each electrophoresis particle of the first electrophoresis particles and the second electrophoresis particles has a spherical segment portion and a reflective layer provided at a bottom of the spherical segment portion, the spherical segment portion having a spherical surface which is a light absorbing surface.

8. The display panel according to claim **7**, wherein in the electrophoresis units corresponding to the pixel units in the non-display state, the reflective layers of the first electrophoresis particles face towards the reflective layers of the second electrophoresis particles, while the reflective layers of the first electrophoresis particles and the reflective layers

of the second electrophoresis particles in the electrophoresis units corresponding to the pixel units in the display state both face towards the pixel units.

9. The display panel according to claim **7**,

wherein the spherical segment portions of the first electrophoresis particles have positive polarities while the reflective layers of the first electrophoresis particles have negative polarities, and the first electrophoresis particles have negative polarities in whole; and the spherical segment portions of the second electrophoresis particles have negative polarities while the reflective layers of the second electrophoresis particles have positive polarities, and the second electrophoresis particles have positive polarities in whole, or

wherein the spherical segment portions of the first electrophoresis particles have negative polarities while the reflective layers of the first electrophoresis particles have positive polarities, and the first electrophoresis particles have positive polarities in whole; and the spherical segment portions of the second electrophoresis particles have positive polarities while the reflective layers of the second electrophoresis particles have negative polarities, and the second electrophoresis particles have negative polarities in whole.

10. The display panel according to claim **5**, wherein a number of the first electrophoresis particles is equal to a number of the second electrophoresis particles in a single electrophoresis unit.

11. A display apparatus, comprising a display panel, the display panel comprising:

a first transparent substrate and a second transparent substrate opposed to each other;

a plurality of double sided light emitting pixel units located between the first transparent substrate and the second transparent substrate and arranged in a matrix;

a plurality of first electrophoresis units located outside of the first transparent substrate and corresponding to odd numbered rows of the pixel units one by one;

a plurality of second electrophoresis units located outside of the second transparent substrate and corresponding to even numbered rows of the pixel units one by one,

wherein each of the first electrophoresis units and the second electrophoresis units comprises a plurality of electrophoresis particles having a first arrangement mode and a second arrangement mode, and

wherein in response to the electrophoresis particles in any first one electrophoresis unit of the first electrophoresis units and the second electrophoresis units being in the first arrangement mode, the first one electrophoresis unit reflects a light emitted from the pixel unit corresponding to the first one electrophoresis unit, while in response to the electrophoresis particles in any second one electrophoresis unit of the first electrophoresis units and the second electrophoresis units being in the second arrangement mode, the second one electrophoresis unit absorbs an ambient light passing through the pixel unit corresponding to the second one electrophoresis unit.

12. The display apparatus according to claim **11**, wherein the first electrophoresis units and/or the second electrophoresis units are configured to control the arrangement modes of the electrophoresis particles such that the electrophoresis particles in the electrophoresis units corresponding to the pixel units in a display state are in the first arrangement mode while the electrophoresis particles in the electrophoresis units corresponding to the pixel units in a non-display state are in the second arrangement mode.

13. The display apparatus according to claim **11**, wherein each electrophoresis unit of the first and second electrophoresis units further comprises a chamber filled with a transparent liquid, the chamber comprising an upper wall with a first transparent electrode layer and a lower wall with a second transparent electrode layer, and a third transparent electrode layer being located between the first transparent electrode layer and the second transparent electrode layer, and the first, second and third transparent electrode layers being spaced apart by the transparent liquid;

wherein the electrophoresis particles comprise first electrophoresis particles and second electrophoresis particles, the first electrophoresis particles and the second electrophoresis particles having opposite whole polarities to each other;

wherein the first electrophoresis particles are located between the first transparent electrode layer and the third transparent electrode layer and the second electrophoresis particles are located between the second transparent electrode layer and the third transparent electrode layer; or the second electrophoresis particles are located between the first transparent electrode layer and the third transparent electrode layer and the first electrophoresis particles are located between the second transparent electrode layer and the third transparent electrode layer.

14. The display apparatus according to claim **13**, wherein each of the first transparent electrode layer and the second transparent electrode layer comprises two transparent electrodes and a masking bar is provided between the two transparent electrodes in the same electrode layer.

15. The display apparatus according to claim **13**, wherein each electrophoresis particle of the first electrophoresis particles and the second electrophoresis particles has a spherical segment portion and a reflective layer provided at a bottom of the spherical segment portion, the spherical segment portion having a spherical surface which is a light absorbing surface.

16. The display apparatus according to claim **15**, wherein in the electrophoresis units corresponding to the pixel units in the non-display state, the reflective layers of the first electrophoresis particles face towards the reflective layers of the second electrophoresis particles, while the reflective layers of the first electrophoresis particles and the reflective layers of the second electrophoresis particles in the electrophoresis units corresponding to the pixel units in the display state both face towards the pixel units.

17. The display apparatus according to claim **15**,

wherein the spherical segment portions of the first electrophoresis particles have positive polarities while the reflective layers of the first electrophoresis particles have negative polarities, and the first electrophoresis particles have negative polarities in whole; and the spherical segment portions of the second electrophoresis particles have negative polarities while the reflective layers of the second electrophoresis particles have positive polarities, and the second electrophoresis particles have positive polarities in whole, or

wherein the spherical segment portions of the first electrophoresis particles have negative polarities while the reflective layers of the first electrophoresis particles have positive polarities, and the first electrophoresis particles have positive polarities in whole; and the spherical segment portions of the second electrophoresis particles have positive polarities while the reflective layers of the second electrophoresis particles have

negative polarities, and the second electrophoresis particles have negative polarities in whole.

18. A display method for a display panel, the display panel comprising:

a first transparent substrate and a second transparent substrate opposed to each other;

a plurality of double sided light emitting pixel units located between the first transparent substrate and the second transparent substrate and arranged in a matrix;

a plurality of first electrophoresis units located outside of the first transparent substrate and corresponding to odd numbered rows of the pixel units one by one;

a plurality of second electrophoresis units located outside of the second transparent substrate and corresponding to even numbered rows of the pixel units one by one, and

wherein each of the first electrophoresis units and the second electrophoresis units comprises a plurality of electrophoresis particles having a first arrangement mode and a second arrangement mode,

the method comprising:

in response to the electrophoresis particles in any first one electrophoresis unit of the first electrophoresis units and the second electrophoresis units being in the first arrangement mode, the first one electrophoresis unit reflects a light emitted from the pixel unit corresponding to the first one electrophoresis unit, while in response to the electrophoresis particles in any second one electrophoresis unit of the first electrophoresis units and the second electrophoresis units being in the second arrangement mode, the second one electrophoresis unit absorbs an ambient light passing through the pixel unit corresponding to the one electrophoresis unit, and

controlling the arrangement modes of the electrophoresis particles such that the electrophoresis particles in the electrophoresis units corresponding to the pixel units in a display state are in the first arrangement mode while the electrophoresis particles in the electrophoresis units corresponding to the pixel units in a non-display state are in the second arrangement mode.

19. The method according to claim **18**, wherein each electrophoresis unit of the first and second electrophoresis units further comprises a chamber filled with a transparent liquid, the chamber comprising an upper wall with a first transparent electrode layer and a lower wall with a second transparent electrode layer, and a third transparent electrode layer being located between the first transparent electrode layer and the second transparent electrode layer, and the first, second and third transparent electrode layers being spaced apart by the transparent liquid;

wherein the electrophoresis particles comprise first electrophoresis particles and second electrophoresis particles, the first electrophoresis particles and the second electrophoresis particles having opposite whole polarities to each other;

wherein the first electrophoresis particles are located between the first transparent electrode layer and the third transparent electrode layer and the second electrophoresis particles are located between the second transparent electrode layer and the third transparent electrode layer; or the second electrophoresis particles are located between the first transparent electrode layer and the third transparent electrode layer and the first electrophoresis particles are located between the second transparent electrode layer and the third transparent electrode layer,

each electrophoresis particle of the first electrophoresis particles and the second electrophoresis particles has a spherical segment portion and a reflective layer provided at a bottom of the spherical segment portion, the spherical segment portion having a spherical surface which is a light absorbing surface,

in the method, the step of controlling the arrangement modes of the electrophoresis particles comprises:

in response to a pixel unit being in a display state, applying a control voltage to the third transparent electrode layer such that the reflective layers of the first electrophoresis particles and the reflective layers of the second electrophoresis particles in the electrophoresis unit corresponding to the pixel unit both face towards the pixel unit to make the reflective layers of the first electrophoresis particles and the reflective layers of the second electrophoresis particles reflect the light emitted from the pixel unit in the display state.

20. The method according to claim **18**, wherein each electrophoresis unit of the first and second electrophoresis units further comprises a chamber filled with a transparent liquid, the chamber comprising an upper wall with a first transparent electrode layer and a lower wall with a second transparent electrode layer, and a third transparent electrode layer being located between the first transparent electrode layer and the second transparent electrode layer, and the first, second and third transparent electrode layers being spaced apart by the transparent liquid;

wherein the electrophoresis particles comprise first electrophoresis particles and second electrophoresis particles, the first electrophoresis particles and the second electrophoresis particles having opposite whole polarities to each other;

wherein the first electrophoresis particles are located between the first transparent electrode layer and the third transparent electrode layer and the second electrophoresis particles are located between the second transparent electrode layer and the third transparent electrode layer; or the second electrophoresis particles are located between the first transparent electrode layer and the third transparent electrode layer and the first electrophoresis particles are located between the second transparent electrode layer and the third transparent electrode layer,

each electrophoresis particle of the first electrophoresis particles and the second electrophoresis particles has a spherical segment portion and a reflective layer provided at a bottom of the spherical segment portion, the spherical segment portion having a spherical surface which is a light absorbing surface,

in the method, the step of controlling the arrangement modes of the electrophoresis particles comprises:

in response to a pixel unit being in a non-display state, not applying a control voltage to the third transparent electrode layer such that the reflective layers of the first electrophoresis particles face towards the reflective layers of the second electrophoresis particles to make the spherical segment portions of the first electrophoresis particles and the spherical segment portions of the second electrophoresis particles absorb the ambient light passing through the pixel unit in the non-display state corresponding to the electrophoresis unit.

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